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DATABASE OF SEISMIC WAVE TRAVEL TIMES IN THE BOHEMIAN MASSIF

DATABÁZE ČASŮ ŠÍŘENÍ SEISMICKÝCH VLN V ČESKÉM MASIVU

Abstract

A number of regional refraction seismic experiments were performed on the territory of the Czech Republic recently. These experiments have produced a relatively great amount of new data. Older data with a comparable quality exist as well. It is definitely advantageous to process and interpret all available data jointly, and to compare current and previous results. According to our experience technical obstacles cause not using all existing data systematically: particular data sets are difficult to obtain and differences in their formats are also significant. The goal of our work was to create a homogeneous database containing times of propagation of nearly all seismic experiments performed on the territory of the Czech Republic, and measured with digital technology.

Introduction

The subject of this paper is to describe our work aiming at collecting the times of propagation of seismic phases from different active seismic experiments and at consecutive unifying of these data. We have considered all available refraction seismic experiments performed on a regional scale, covering at least partially the region of the Czech Republic and using digital measurement technology. Such experiments may be roughly characterised by the following:

- seismic waves are generated by firing of ~10^2 kg of explosive
- the measuring geometry is linear
- the distance between closest shot-points is ~10^1 km
- the distance between closest receivers is ~10^0 km
- sampling period is 4-50 ms
- Pg, Pn and PmP phases are picked in the epicentral range 0–250 km.

We have compiled data from experiments listed in the following table.

Name of the experiment	*Measured in*	*References*
Dekorp 3 shots recorded on the Czech territory	1990	www.gfz-potsdam.de/pb3/dekorp/welcome.html
Celebration 2000	2000	Guterch et al.2003a Málek et al.2001
Celebration 2000 shots recorded by CRNS*	2000	Růžek et al.2003 Hrubcová et al.2004
Mining induced events in Ostrava coal mines	2000-2003	-
Alp 2002 receivers used for recording a big shot in a circular configuration	2002	Vavryčuk et al.2004
Alp 2002	2002	Guterch et al.2003b
Alp 2002 and Sudetes 2003 shots recorded by CRNS*	2002/2003	Zedník et al.2004

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Name of the experiment	*Measured in*	*References*
Sudetes 2003	2003	Grad et al.2003
Shots recorded within the grant project GACR 205/03/0999	2004/2005	Růžek et al. 2004a,b Holub et al.2004

*CRNS = **C**zech **R**egional **S**eismological **N**etwork

All these data are inhomogeneous due to more reasons. Co-ordinates may be either geographical (φ,λ) or local cartesian (X,Y). Times of propagation may be either given directly, or times of arrivals plus shooting time are defined. It may not be evident, which phases were picked. The precision depending also on the sampling rate of original recordings may be different. The particular digital format of original waveform data is definitely individual for each source of data. For all this reasons, archive data are not used appropriately. We tried to collect all these data and to homogenize them. We have created database tables sharing an unique format. We believe, that now the utilization of corresponding information is easy and straightforward. All tables are accessible on request via e-mail b.ruzek@ig.cas.cz. Nevertheless, we know that our database is still incomplete and it has to be upgraded in the future. Recently, the most appropriate source of data is the sequence of BOHEMA experiments (e.g. Babuška et al. 2003). These data will be definitely included as soon as possible, depending on the agreement of the research team managing the data.

Database Structure

Our database is very simple in fact. It consists of three related tables: (i) table of shots, (ii) table of stations/receivers, and (iii) table of readings.

Example of three lines of the table of shots:

ID	FI	LAMDA	Z	Y	X	YR	MO	DATE	HR	MIN	SEC	CHRG
26910	50.2167	12.6683	399	864.648	1010.350	2000	6	25	3	15	0.113	200
26901	50.5631	13.7252	220	784.508	983.738	2000	6	24	3	45	1.295	10710
20030	47.4262	14.5148	1448	776.207	1337.237	2000	6	24	3	0	0.379	300

All shot positions are given simultaneously in geographic co-ordinates (in WGS-94 system) and also in commonly used Křovák's cartesian local system JTSK (Y,X columns). Shooting time and fired charge are also included provided this information is available (the absence of shooting time is not critical, since travel times are present any time in the last table of readings). The first column contains identification of the shot (it may be a number or text). Next table - station/receiver one is similar to the shot table, but it is even simpler:

Example of three lines of the table of stations/receivers:

ID	FI	LAMDA	Z	Y	X
21003	50.5987	13.7438	220	782.627	980.010
21004	50.5659	13.7060	230	785.805	983.234
21005	50.5497	13.7361	320	783.964	985.324

Again, the first column identifies the station/receiver and co-ordinates are given both in geographical and cartesian systems. Finally, times of propagation are given in the last table:

Example of three lines of the table of readings:

Shot_ID	Stat_ID	distance	phase1	phase2	...	phase10
31010	21003	3451	0.947	...	...	...
31010	21004	1080	0.608	...	...	...

Shot_ID	Stat_ID	distance	phase1	phase2	...	phase10
31010	21005	2964	0.868	...	...	...

Currently, our table of readings has 10 columns for 10 seismic phases, but it may be made broader in the future. Now we have actual readings of Pg, Sg, Pn, and PmP phases. First two columns in the table of reading are used for identifying corresponding shot and receiver positions. Third column is epicentral distance included for the purposes of fast selection of data.

Content of the Database

Our database contains 17272 readings at the moment. Most of the readings correspond to Pg phase. S waves are present only occasionally, they were picked on three-component recordings from permanent stations of CRNS. Figures 1 – 3 give a simple illustration of the database content.

Possible Areas of the Database Utilization

Fig.4 shows that the best ray coverage is in Western Bohemia, namely in the seismoactive region <12°00'E - 14°00'E> x <49°45'N - 50°30'N> (details in fig.5). This region is known for periodic occurrence of seismic swarms (e.g. Horálek et al. 2000, Fischer and Horálek 2003 and many others, see also http://www.ig.cas.cz/seismo/Webnet/refer.php). Local seismic network 'Webnet" consisting of 12 seismic stations continuously monitors the seismic activity in the region. Thousands of earthquakes were recorded and located up to now. The characteristic depth of hypocenters is in the range 6-10 km. It would be an excellent opportunity and a challenge to combine our database and Webnet earthquake catalogue in order to perform full 3D seismic tomography. All previously performed inversions of seismic data were more or less lacking of inappropriate knowledge about the velocity model. Either homogeneous halfspace, or highly simplified 1D gradient or layered velocity models were used.

A simple and instructive way how to use our database is shown in the next example. All Pg phases in the epicentral range 0-120 km were selected and used for interpretation using the „time-term" method (e.g. Bamford 1977). All static „station" corrections, all „shot" corrections and optimum velocity of Pg waves propagation are searched for simultaneously in this approach. The method leads to the solution of underdetermined linear problem, so some regularization needs to be applied. We used the requirement that both „station" corrections and „shot" corrections have the same mean value. This supplementary condition is relevant since all shots were fired in places where stations were recording and vice versa. The results are in a good agreement with regional geology (fig.6).

The third example deals with the solution of our grant project GAČR No. 205/03/0999 „The velocity model and shallow geologic building in the Moravo-Silesian region". During first two years of this project, we succeeded in getting 277 seismic rays covering the area of interest (fig.7a). Our data may be supplemented by archive data from the discussed database. By doing so we got total of 1602 rays (fig7b). The new coverage is definitely denser and there is no doubt that corresponding inversions will be much more stable and reliable.

Conclusions

Our results may be summarized in the following:

- Using data from our database is easy and advantageous
- It is highly recommended to revise the potential of archive data in the stage of planning and before launching new seismic experiments
- It is desirable to complete missing data and upgrade the database
- It is necessary to follow new experiments and to include them into the database whenever possible
- Our database is open to all interested parties via e-mail b.ruzek@ig.cas.cz.

Acknowledgement
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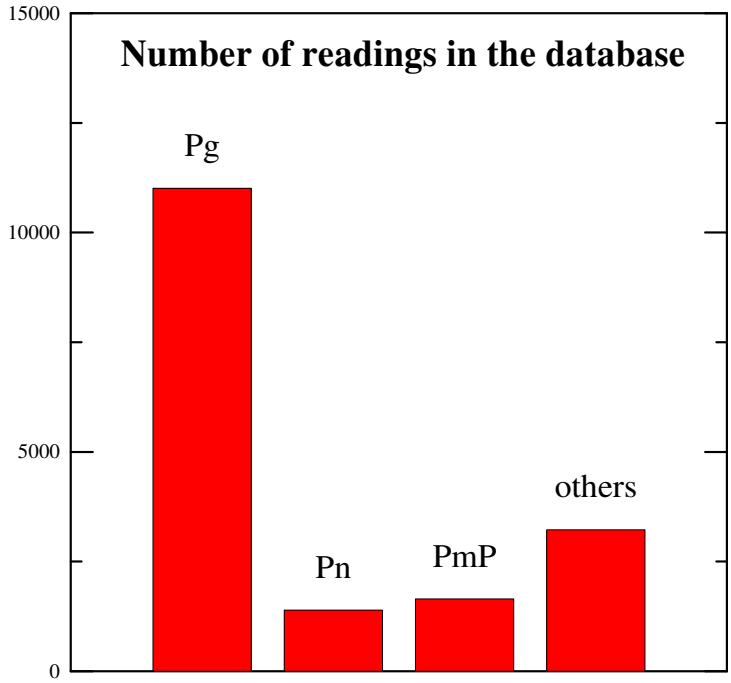


Fig.1 Distribution of times of propagation present in the database according the seismic phase. The column „others“ includes unidentified intracrustal reflections and all S waves

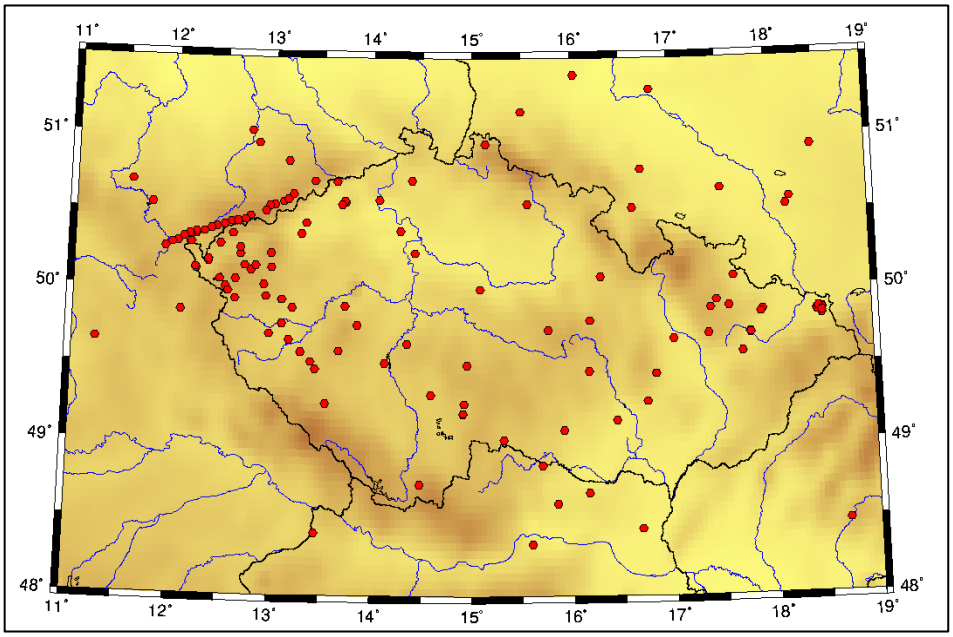


Fig.2 Positions of shots

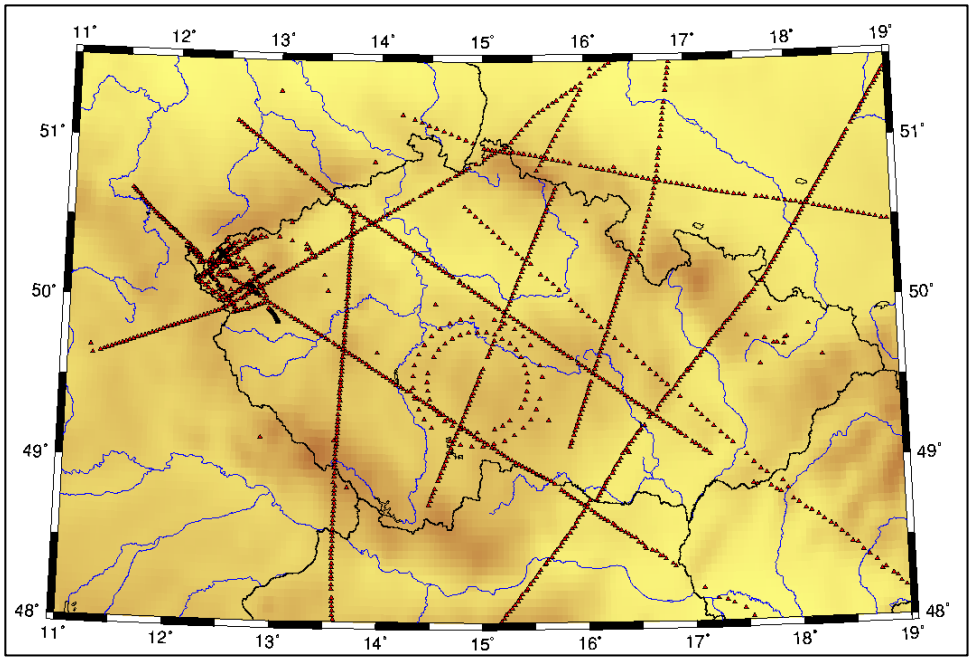


Fig.3 Positions of stations/receivers

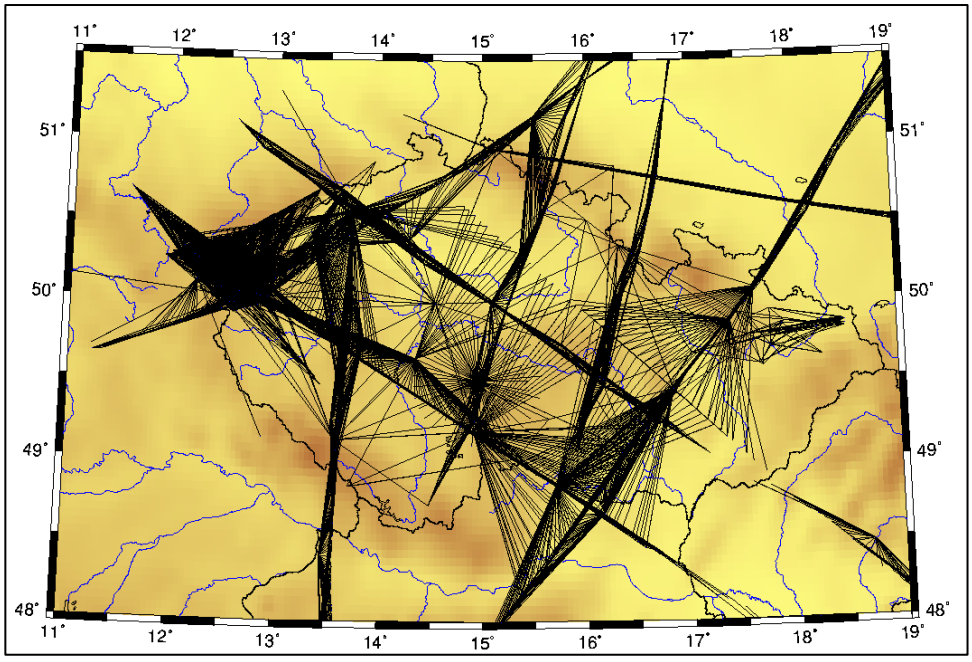


Fig.4 Available rays

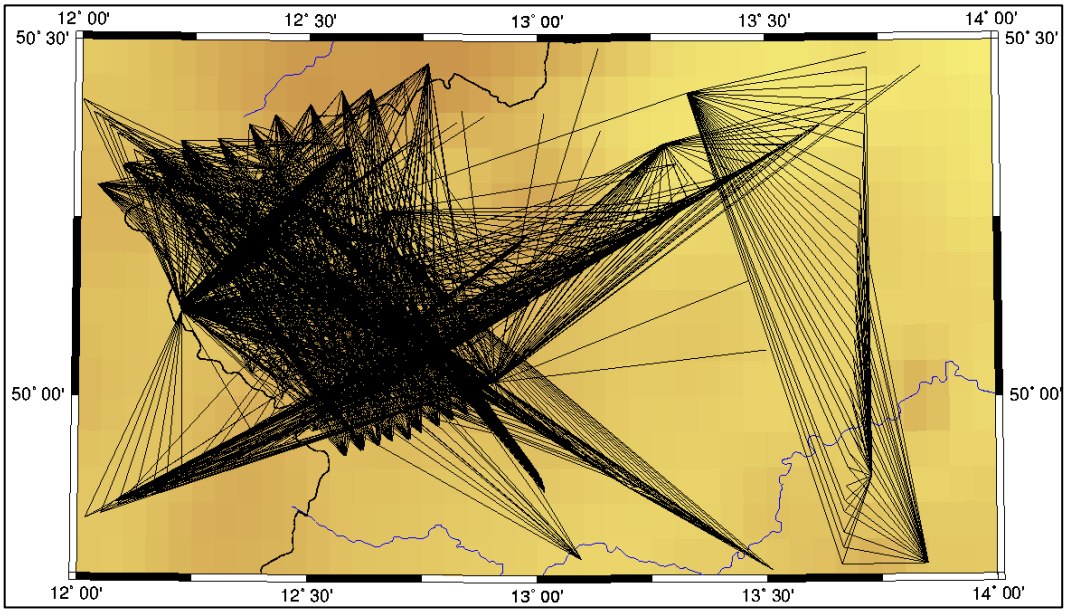


Fig.5 Rays crossing the seismoactive area in Western Bohemia

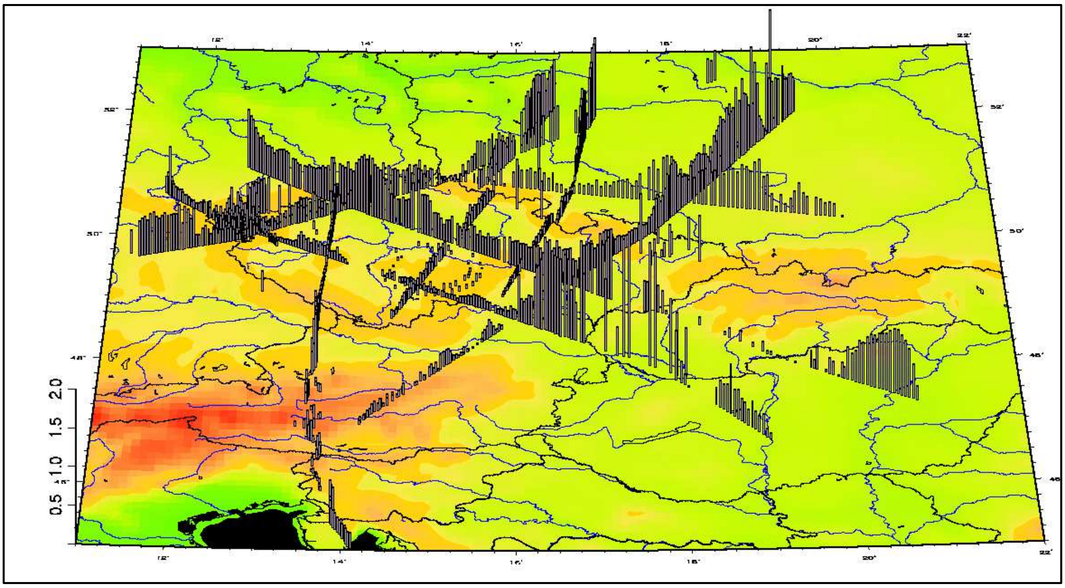
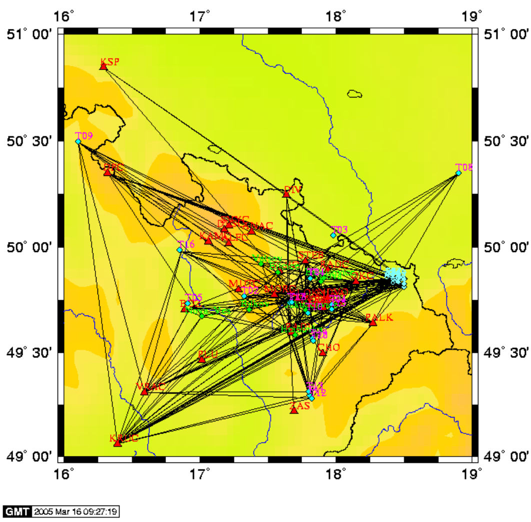


Fig.6 Time corrections of Pg phases



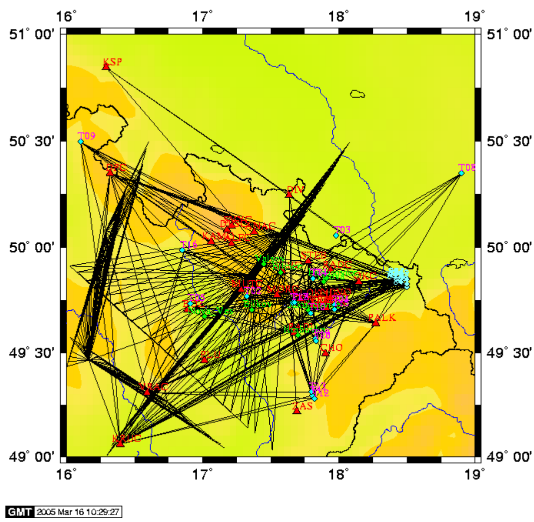


Fig.7a(left) 7b(right) Rays in the Moravo-Silesian Region obtained by our own measurements (7a), and all relevant rays including our measurements plus rays from the database (7b)